Juvenile salmon and nearshore fish use in shallow intertidal habitat associated with Dugualla Heights Lagoon, 2011

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2006 oblique aerial photo of Dugualla Heights Lagoon (courtesy WA Department of Ecology)

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Purpose of report

Restoration and protection of Dugualla Heights Lagoon was identified as a priority in the Skagit Chinook Recovery Plan (page 216 in SRSC & WDFW 2005) because of its importance to early rearing of wild fry migrant Chinook salmon originating from the Skagit River. In 2009 the area was protected with a conservation easement and a restoration feasibility study was funded by Washington State's Salmon Recovery Funding Board (SRFB), with the project's sponsor being the Whidbey Camano Land Trust (http://www.wclt.org/projects/dugualla-heights-conservation-easement/). Restoration concepts at Dugualla Heights include improvement of tidal connectivity and fish passage to the lagoon from Skagit Bay.

As part of the feasibility study, the Skagit River System Cooperative Research Program is responsible for presenting a report to Whidbey Camano Land Trust describing fish use of the study area before restoration. The objective of beach seining at Dugualla Heights in 2011 was to collect data on the fish assemblage, including juvenile salmon, present in the waters of Dugualla Heights Lagoon and shoreline areas of Skagit Bay near the outlet of the lagoon. Data from this monitoring effort are used to document fish species composition and relative fish abundance prior to any restoration completed at this site. Pre-restoration project fish results serve as a basis for measuring the response of the fish community to restoration at Dugualla Heights.

Study area

Dugualla Heights Lagoon and shoreline are part of the Puget Sound nearshore (Figure 1). The Puget Sound nearshore, as defined by the Puget Sound Nearshore Ecosystem Restoration Program, includes the Puget Sound fjord, Hood Canal, Whidbey Basin, the Strait of Juan de Fuca, the San Juan Islands, and the mainland coast to the Canadian border. Within the nearshore, coastal and upland processes interact to form a diversity of intertidal, subtidal, and terrestrial habitats. Coastal processes (wind waves, tides) create coastal habitats such as spits, dunes, tidal channels, lagoons, and salt marshes, while watershed processes (streams, groundwater seeps, rivers) contribute freshwater to the nearshore and create habitats like delta flats, marsh islands, and distributary channels.

Dugualla Heights Lagoon is part of a group of nearshore habitats referred to as pocket estuaries. Pocket estuaries are partially enclosed bodies of marine water that are connected to a larger estuary (such as Puget Sound) at least part of the time, and are diluted by freshwater from the land at least part of the year (after Pritchard 1967). These small estuaries are differentiated from larger scale estuaries because the watersheds they are associated with are too small to support salmon spawning populations; thus we call them non-natal estuaries with respect to juvenile salmon use (Beamer et al. 2003). Pocket estuaries are an important habitat for wild Chinook salmon fry early in the year once they leave their natal estuary and enter nearshore areas of Whidbey Basin (Beamer et al. 2003 and 2006b).

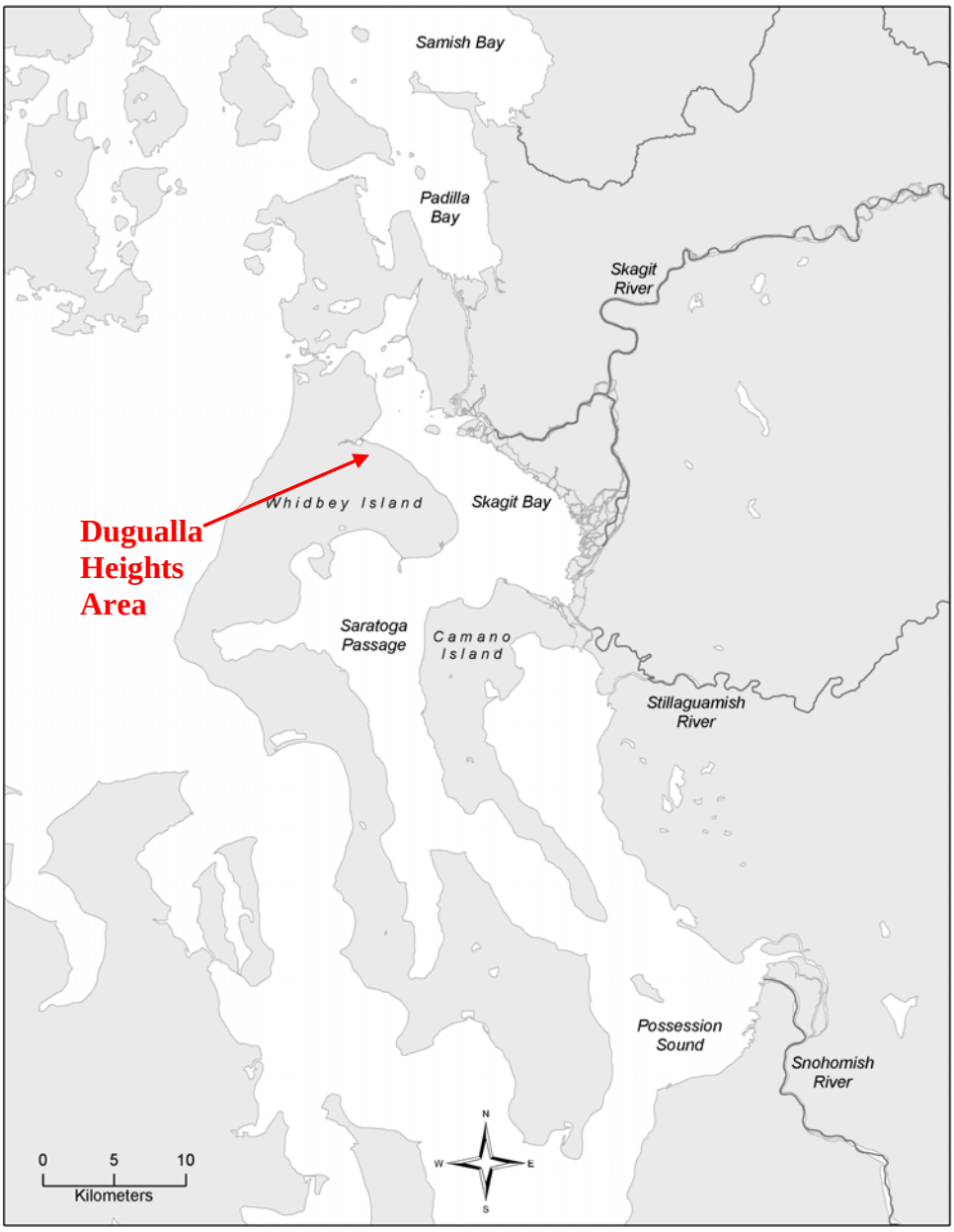


Figure 1. Location of Dugualla Heights area along the northeastern shoreline of Whidbey Island within Skagit Bay.

Monitoring hypotheses

Many fish species are expected to benefit from restoration at Dugualla Heights, but we specifically hypothesize that pre-restoration conditions at Dugualla Heights in 2011 would show:

1. few (or no) fry sized Chinook and chum salmon in the lagoon, but that
2. fry sized Chinook and chum salmon are in the vicinity of the lagoon.

After restoration (i.e., improved tidal connectivity and fish passage to the lagoon), we hypothesize:

3. juvenile fry sized salmon to be present within the lagoon during the same months they are present in the vicinity of the lagoon, and
4. fry sized Chinook salmon are more abundant inside the lagoon early in the year than in the immediate vicinity of the lagoon within Skagit Bay.

Sampling methods, effort, and period

We sampled using a small net beach seine within Dugualla Heights Lagoon and its adjacent shallow intertidal nearshore habitat. The specific beach seine locations are shown in Figure 2. The areas seined are typically less than five feet deep (1.5 m), and have relatively homogeneous habitat features (water depth, velocity, substrate, vegetation). Small net beach seine methodology uses an 80-foot (24.4 m) by 6-foot (1.8 m) by 1/8-inch (0.3 cm) mesh knotless nylon net. The net is set in "round haul" fashion by fixing one end of the net on the beach while the other end is deployed by wading "upstream" against the water current (if present), hauling the net in a floating tote, and then returning to the shoreline in a half circle. Both ends of the net are then retrieved, yielding a catch. One beach seine set was made at each site per sampling day. Average beach seine set area was 96 square meters. Photos of the methods and further description are found within a methods paper published by Skagit System Cooperative (2003).

For each beach seine set, we identified and counted the catch by species. We also recorded the time and date of each beach seine set and measured several water quality variables associated with each set, including water temperature, salinity, and dissolved oxygen using a YSI Professional Plus Model meter.

The Dugualla Heights sampling effort in 2011 consisted of 84 beach seine sets made during the February through May time period (Table 1). Beach seine effort within the lagoon was equal to the effort in adjacent shallow nearshore based on the number of sets sampled in each area. While we only have two "sites" shown in Figure 1 for adjacent nearshore, we did make three beach seine sets at each of the two sites for a total of six beach sets each sampling date.

Table 1. Summary of beach seine effort (number of sets) at Dugualla Heights, 2011.

Beach Seining Date	Adjacent Nearshore	Lagoon	Total
17-Feb-11	6	6	12
02-Mar-11	6	6	12
15-Mar-11	6	6	12
11-Apr-11	6	6	12
27-Apr-11	6	6	12
12-May-11	6	6	12
27-May-11	6	6	12
Total	42	42	84

Figure 2. Location of beach seine sites at Dugualla Heights, 2011. Yellow circles represent sites within the lagoon. White squares represent sites in the adjacent nearshore. The photo was taken at high tide. Beach seining was always done at the water's edge, regardless of tidal stage. We targeted our sampling time to coincide with higher tides.

Results and brief discussion

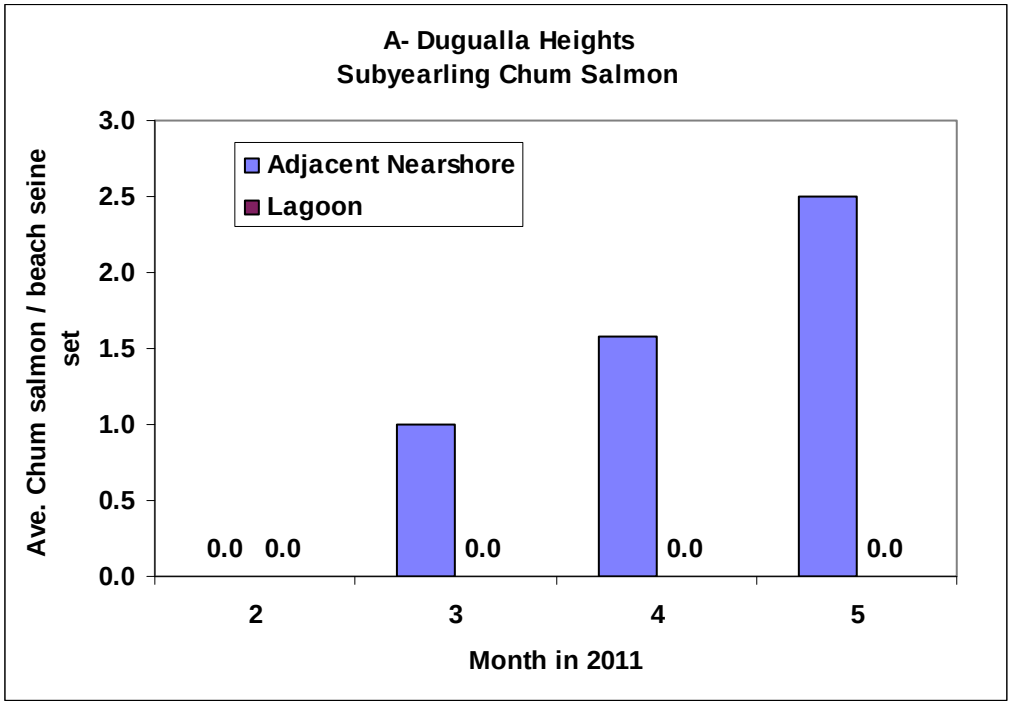
Fish

We caught 4,049 individual fish representing 13 different species during the sampling period February through May, 2011 (Table 2).

Table 2. Total fish catch (and mean catch per beach seine set in parentheses) by species at Dugualla Heights sites in 2011.

Species	Adjacent nearshore	Lagoon
Salmon:		
Chum salmon, subyearling *Oncorhynchus keta*	61 (1.45)	0 (0.00)
Chinook salmon, unmarked subyearling *Oncorhynchus tshawytscha*	70 (1.67)	0 (0.00)
Chinook salmon, hatchery released yearling *Oncorhynchus tshawytscha*	1 (0.02)	0 (0.00)
Bull trout, adult, *Salvelinus confluentus*	1 (0.02)	0 (0.00)
Cottids (sculpins):		
Pacific staghorn sculpin *Leptocottus armatus*	305 (7.26)	283 (6.74)
Flatfishes:		
Starry flounder *Platichthys stellatus*	19 (0.45)	6 (0.14)
Forage fish:		
Surf smelt *Hypomesus pretiosus*	18 (0.43)	462 (11.00)
Other nearshore or estuarine fishes:		
Shiner perch *Cymatogaster aggregate*	386 (9.19)	1 (0.02)
Threespine stickleback *Gasterosteus aculeatus*	257 (6.12)	2162 (51.48)
Bay pipefish *Syngnathus leptorhynchus*	0 (0.00)	9 (0.21)
Tubesnout *Aulorhynchus flavidus*	1 (0.02)	0 (0.00)
Crescent gunnel *Pholis laeta*	1 (0.02)	0 (0.00)
Saddleback gunnel *Pholis ornata*	5 (0.12)	0 (0.00)
Pacific tomcod *Microgadus proximus*	0 (0.00)	1 (0.02)
All fish	1,125 (26.79)	2,924 (69.62)
Selected invertebrates:		
Juvenile Dungeness crab *Metacarcinus magister* (formerly *Cancer magister*),	2 (0.05)	92 (2.19)

The juvenile salmon catch was about 3% of the total fish catch and was roughly equally represented by subyearling chum and Chinook salmon. Juvenile chum and Chinook salmon were only caught in adjacent shallow nearshore habitat; none were caught in the lagoon (Table 2, Figure 3). No juvenile pink and coho salmon were caught. Juvenile pink salmon in 2011 would have been the progeny of even-year spawning adults, which are not common in Puget Sound. Coho salmon were not likely to be caught because they do not readily occupy shallow intertidal habitats due to their larger size at seaward migration. No cutthroat (any age), juvenile steelhead or sockeye were captured. One adult bull trout was caught in adjacent shallow nearshore habitat. No bull trout were caught in the lagoon.



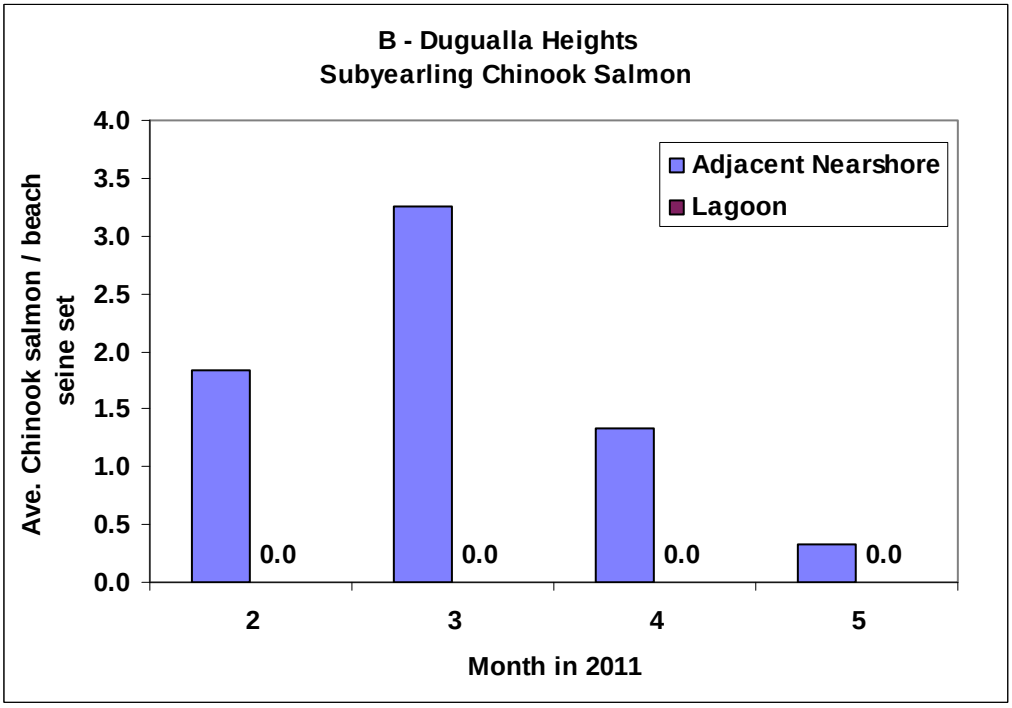


Figure 3. Average monthly juvenile salmon CPUE for Dugualla Heights Lagoon and its adjacent nearshore habitat, 2011. No juvenile Chinook or chum salmon were caught in the lagoon. No juvenile chum salmon were caught in adjacent shallow nearshore habitat in the month of February.

Threespine stickleback accounted for nearly 60% of the total catch. Based on catch per unit effort (CPUE) calculated as fish per beach seine set, sticklebacks were over eight times more abundant in the lagoon than in the adjacent shallow nearshore habitat. Sculpins, which consisted only of Pacific staghorns, accounted for over 14% of the total catch. Based on CPUE, staghorns were roughly equal in their abundance in the lagoon and adjacent shallow nearshore habitat.

Shiner perch accounted for nearly 10% of the total catch. Shiner perch were much more abundant in adjacent shallow nearshore habitat; only one shiner perch was caught in the lagoon. Surf smelt (mostly juveniles) accounted for nearly 12% of the total catch. Surf smelt were the only forage fish species caught in the study area. No herring, sand lance, or anchovy were caught. Based on CPUE, surf smelt were over 25 times more abundant in the lagoon than in the adjacent shallow nearshore habitat.

Macro invertebrates

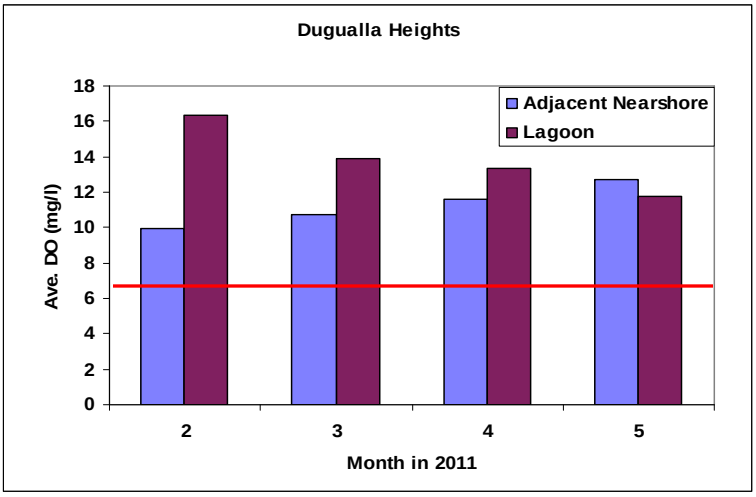
Macro invertebrate (such as crab) catches were incidental to our fish catches. We counted sub-legal Dungeness crab (mostly juvenile sized with a carapace width typically < 100 mm) caught in the beach seine. Based on CPUE, juvenile Dungeness crab were much more common in the lagoon than in the adjacent shallow nearshore habitat, indicating this area is a nursery area for Dungeness crab.

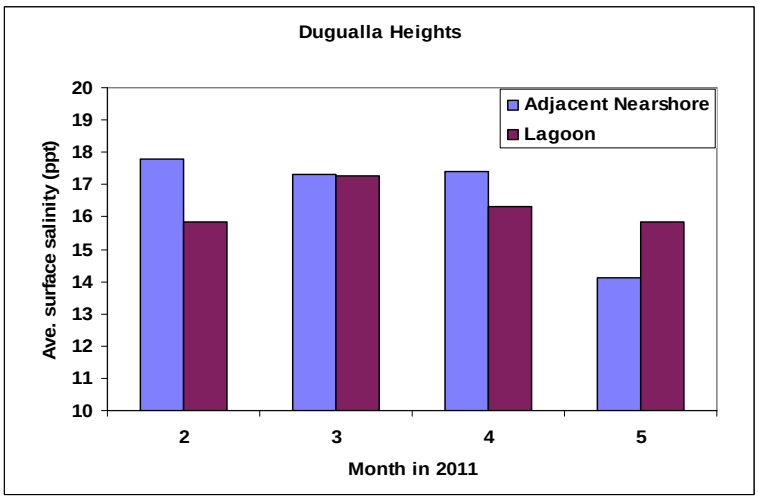
Water quality

Dissolved oxygen levels at Dugualla Heights showed a monthly decrease in the lagoon and slight increase in adjacent nearshore habitat during our sampling period (Figure 4, top panel). However, dissolved oxygen in the lagoon and adjacent shallow nearshore habitat was consistently better than standards set by Washington State for marine waters. All measurements were taken during daylight hours. Dissolved Oxygen can have diurnal fluctuations due to aquatic plant and algal influences.

Salinity at Dugualla Heights is influenced by the amount of Skagit River water flowing into Skagit Bay as well as a small stream directly flowing into the lagoon. Salinity levels at Dugualla Heights are consistent (or lower) with levels of other Whidbey Basin lagoon type pocket estuaries that are known to support juvenile salmon rearing (Beamer et al. 2009; Beamer et al. 2006a; Henderson et al. 2007; Kagley et al. 2007).

Water temperature at Dugualla Heights shows a monthly increase in the lagoon and adjacent nearshore habitat. Starting in March, the lagoon is warmer than adjacent nearshore habitat. Water temperature higher than 15°C has been postulated as stressful to juvenile Chinook salmon rearing in estuarine habitats (Fresh 2006, page 4). He hypothesized that as water temperature increases beyond 15°C, the increased stress on fish results in a movement response of fish from shallower habitats to deeper habitats, or to more marine habitats altogether. The observed pattern of water temperature at Dugualla Heights is expected, and likely a controlling factor in why we expect pocket estuaries to be a nursery habitat for juvenile salmon only during late winter to early summer months.





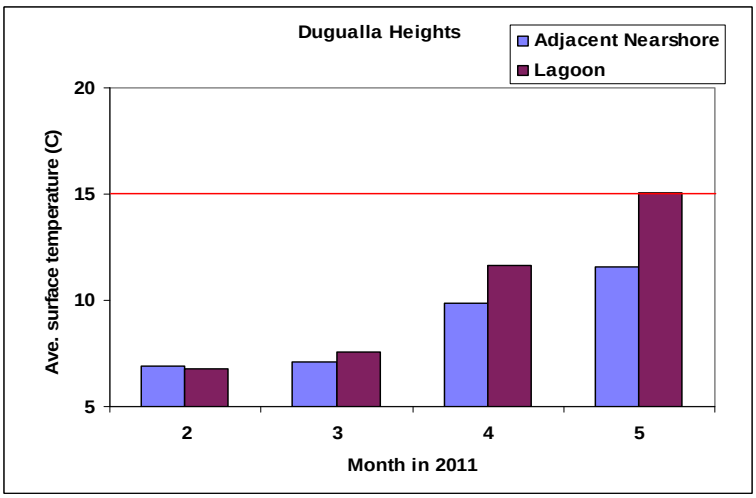


Figure 4. Summary of dissolved oxygen (top panel), salinity (middle panel), and water temperature (bottom panel) measured at Dugualla Heights, 2011. The red lines are threshold lines for temperature (>15°C, based on Fresh 2006) and dissolved oxygen (< 7.0 mg/l, Washington State Extraordinary water quality standard for salmonid and other fish migration and rearing in marine waters). Exceeding either threshold is considered unhealthy for juvenile salmon.

Pre-restoration project conclusions

Beach seining during these months of 2011 provide one year of before-restoration project fish assemblage results at the Dugualla Heights site during the months when juvenile Chinook and chum salmon fry could colonize habitat in this area.

No juvenile salmon were caught inside Dugualla Heights lagoon, suggesting the lagoon is not well connected to the source of juvenile salmon, i.e., the adjacent nearshore habitat of Skagit Bay. Juvenile salmon, migrating mainly from the Skagit River, would be expected to migrate to the vicinity of Dugualla Heights Lagoon. Sampling adjacent nearshore habitat near the outlet of the lagoon showed consistent monthly presence of wild juvenile subyearling Chinook salmon and chum salmon fry (Figure 3). Environmental conditions within the lagoon indicate the lagoon can support rearing of juvenile salmon early in the year (Figure 4), so it's unlikely that unsuitable habitat conditions account for us finding no salmon in the lagoon in 2011.

Shiner perch show the same result as juvenile salmon; they were essentially absent from the lagoon during our sampling period. Shiner perch are a schooling fish that occupy shallow protected nearshore areas in spring and summer months. Shiner perch are common in other lagoon type pocket estuaries with natural outlet conditions within the Whidbey Basin (Beamer et al. 2009; Beamer et al. 2006a; Henderson et al. 2007; Kagley et al. 2007).

Two fish species (surf smelt and staghorn sculpin) and juvenile Dungeness crab were consistently caught inside the lagoon. Like juvenile salmon and shiner perch, these species would be expected to access the lagoon from Skagit Bay because their populations do not originate from within the lagoon. The fact that these species were consistently observed in the lagoon suggests there is biological connectivity between adjacent habitat within Skagit Bay and the lagoon at least during some time of the year. Restoration at Dugualla Heights would not likely have a negative effect on these species. It is likely these species have different (i.e., less constraining) passage criteria than juvenile fry sized salmon.

Sticklebacks are tolerant of varying habitat conditions and can live out their life cycle in fresh, brackish, or marine waters. It would not be surprising to observe high densities of sticklebacks inside the lagoon over a wide range of tidal connectivity conditions with Skagit Bay.

Lagoon type pocket estuaries with natural outlet conditions in Skagit Bay consistently have much higher densities of wild juvenile Chinook salmon inside their lagoon or marsh habitat than adjacent nearshore habitat (Figure 5). The Dugualla Heights result in 2011 is very different than observations collected at the five different pocket estuaries over six years with natural outlet conditions shown in Figure 5. Over the six-year period and five different pocket estuaries studied, never did we find a cumulative density of wild juvenile Chinook salmon inside the pocket estuary to be lower than in its adjacent nearshore habitat for the early rearing period of fry migrant Chinook salmon (February through May).

Restoration goals at Dugualla Heights include improvements in: 1) tidal inundation of the lagoon and 2) fish passage opportunity sufficient for juvenile fry sized salmon to access and egress the lagoon. If restoration is completed at Dugualla Heights, it will likely change the result that was observed in 2011, of no juvenile salmon inside the lagoon, to some juvenile salmon utilizing the lagoon. However, a simple change from "not present" to "present" is not an ideal for a site so strategically located near the mouth of the Skagit River, a source of juvenile salmon known to be capable of colonizing pocket estuary habitat. We recommend the biotic objectives of Dugualla Heights restoration for wild juvenile Chinook salmon mimic the patterns observed at naturally functioning pocket estuaries, such as those shown in Figure 5, and that restoration designs be used that would achieve such objectives.

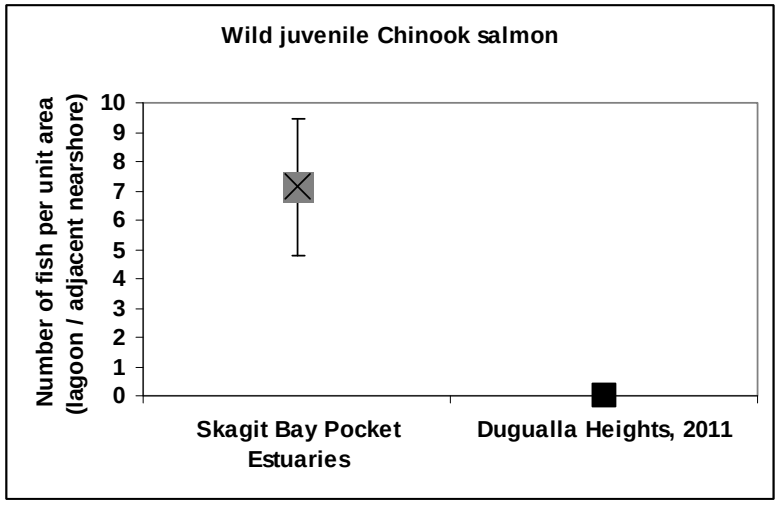


Figure 5. Relative difference in wild juvenile Chinook salmon density in pocket estuary habitat compared to adjacent nearshore habitat for pocket estuaries with natural outlet conditions in Skagit Bay. The median value is 7.1 times more juvenile Chinook salmon per unit area inside pocket estuary habitat than its adjacent nearshore for the rearing period February through May. The error bars are 95% confidence limits. Results are shown for 5 pocket estuaries (Arrowhead Lagoon, Kiket Lagoon, Lone Tree Lagoon, Old Bridge Saltmarsh, and Turners Bay) over 6 years (2003 – 2007, and 2009) in Skagit Bay. The total number of wild juvenile Chinook observations is 15 for Skagit Bay pocket estuaries with natural outlet conditions. Data are from SRSC Research program: Beamer et al. 2003 and Beamer et al. 2006b. Only one year of data is available for Dugualla Heights (2011). No juvenile Chinook salmon were caught inside the lagoon at Dugualla Heights in 2011.

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